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van Geenhuizen, M.; Nijkamp, P.

Faculteit der Economische Wetenschappen en Econometrie

Serie Research Memoranda

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Marina van Geenhuizen
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Research Memorandum 1995-28

vrije Universiteit *amsterdam*

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Marina van Geenhuizen * and Peter Nijkamp

July 1995

Free University Amsterdam
Department of Regional Economics
Tel. 31-20-4446090
Fax. 31-20-4446005

Paper for the seminar "Innovation and restructuring as a challenge for regional development policy", Warsaw, 14-17 September 1995.

* Present address: University of Technology Delft, Faculty of Systems Engeneering and Policy Analysis, Jaffalaan 5, 2628 BX DELFT, The Netherlands. Tel: 31-15-786729; FAX: 31-15-783422.

ABSTRACT

It has become increasingly evident that technology is a major determinant of the competitiveness of cities and regions nowadays. The availability of new technology essentially reduces the amount of uncertainty with which companies deal in their daily operations. In addition, new technology is a basis for the establishment of new companies and the restructuring of old ones. It therefore, may essentially influence the development direction of urban and regional economies.

First, this paper will discuss a communication approach to technology transfer. This approach pays attention to barriers and the removing of barriers in communication processes underlying technology transfer (Section 2). Next, in an empirical part, the paper will focus on experiences in technology transfer through academic transfer institutes (Section 3) and science parks (Section 4). This analysis is based on a blend of empirical studies in Europe and the United States. The paper will conclude with an examination of practica1 issues concerning obstacles to technology transfer (Section 5). To this purpose it provides an evaluation framework for the assessment of potential success of new science parks, namely by means of the so-called 'Pentagon of Concerns'. It will be discussed how this evaluation framework can be operationalized by means of multi-criteria analysis.

1. Introduction

Europe is currently facing an unprecedented disappearance of many man-made politica1 borders. Whereas the European Union is undertaking further steps towards its integration, Eastem Europe is going through a process of transformation in which closer linkages are being sought with nations of the European Union. Whether these developments lead to an open society for the benefit of all actors involved remains, however, to be seen.

Vanishing borders mean the opening of regional economies to new networks and new social and economic influences, introducing particularly an increased competition between regions and between cities (cf. Cheshire and Gordon 1995). Such a competition creating win-lose situations, may imply the increase of regional disparities in employment levels and welfare. High levels of unemployment are apparent in all large cities in Western and Eastern Europe, but it is particularly evident in countries facing an economic transformation which causes specific industries to close down. The latter process is not sufficiently compensated by the establishment of new activities, leading to a net loss of jobs (Gorzelak et al. 1994; Jackson et al. 1995). Unemployment in Eastem Europe is of great concern, particularly because it strongly affects young people (Kabaj 1995). In the most worse scenario for European regions, the opening of regional economies leads to the emergence of a 'Golden Curtain', dividing the rich West from the poor East (Gibb and Michalak 1994).

It is increasingly realized that the actual competitive advantage of city regions in the European Union is brought about by the local presence of science and technology, particularly in research laboratories and enterprises (Hingel 1993). Both in Western and Eastem Europe, the economic base of cities is being transformed from commodity-based activities in the production sector to knowledge-based activities in the knowledge sector (or broadly, the service-sector). Science therefore, should be regarded and treated by urban planners and politicians as a source of economic power (Knight 1994). Accordingly, it is a major challenge for European cities to formulate policies for enhancing and valorizing their knowledge cultures and transforming knowledge into local economic development.

The current 'national systems of innovation' in Eastem Europe are stil1 very much influenced by the peculiar features of the communist past (Freeman 1994). First, there was a relative weakness of R and D and innovation on the enterprise level. Innovation and R and D were traditionally found in branch level institutes. A second feature was the relatively large contribution of the 'Academy' system to basic and applied research. Consequently, there were no strong links between knowledge sources and enterprises. A third factor was the almost entire isolation from the world economy and Western technology sources for decades. Nowadays, the university and its new generation of young engineers and scientists form the greatest hope for the future development of technology and innovation in Eastem Europe (Freeman 1994).

It has become increasingly evident that R and D in the European Union is strongly concentrated in a few 'islands' in each country. Research laboratories and enterprises in these few 'islands' work intensively together in highly exclusive networks (Hilpert 1992; Hingel 1993). Due to a long history of separation, R and D 'islands' in the European Union are not very well linked up with Eastern Europe. What makes this situation worse nowadays is that financial limitations prevent Eastem European scholars from participating in international research networks (Dyker 1994).

Fast-growing 'high tech' regions have increasingly attracted attention from policy makers and planners as models of industrial revitalization. By means of promoting links between universities and industry, and establishing science parks and incubation centres many planners have sought to replicate the success of these regions. Northern California's Silicon Valley and Boston's Route 128 are the most celebrated examples of such regions (Saxenian 1994).

This paper will investigate the potential role of universities and other research institutes in the commercialization of technology and concomitant employment growth. To this purpose it will first discuss a communication approach to the analysis of technology networking in the next section.

2. A Communication Approach

Technology transfer can be defined as bringing technology to market. A relatively new approach regards technology transfer as a specific process of communication, subject to various types of barriers (cf. Williams and Gibson 1990). In an actor-oriented communication approach, one can distinguish senders and receivers of information. Communication encompasses the following stages (cf. Ouwersloot 1994; Kamann 1993):

information: selection of message by sender
representation: production of a signal that uses a certain coding and vehicle of comrnunication
transfer of the signal
interpretation: decoding of the signal into a message by the receiver
reception of the message by the destination.

It needs to be emphasized that the above linear model is a simple one. In reality, communication is often an interactive process including various feed-back loops between receiver and sender. In this respect, communication can also be conceived of in terms of convergence, in which senders and receivers commtmicate interactively with the purpose of reaching a particular convergence point where both agree (Rogers and Kincaid 1981).

In communication on technology different vehicles may be used (Dosi 1988; Geenhuizen 1994), namely:

human capita1 (this concerns ideas, expertise, skills and routines residing in employees and managers)
- written language (e.g. data files, manuals, specifications, scientific journals)
- oral language (on-site instruction, audio representation, etc.)
- hardware (such as devices, equipment, materials)
- tacit or visual representation (transfer by observing, doing and imaging).

Comrnunication is subject to influences that may prohibit a smooth flow of information. Barriers to communication are indicated by discontinuities in the intensity of information flows in time and space. Such barriers have a widely different origin, dependent upon the perspective used such as spatial interaction (networking), innovation diffusion, and particularly communication (cf. Brown 1981; Davies 1979; Geenhuizen 1994; Kamann 1994; Nijkamp et al. 1990; Suarez-Villa et al. 1992; Williams and Gibson 1990). Analytically, a distinction can be made between the nature of the technology itself, characteristics of senders and receivers as actors in communication, institutional factors, and time and space (Table 1). Some barriers are inherent in the nature of communication and networking. A common example of this type of barriers is the genera1 inertia of networks, in view of extension with new participants (cf. Håkansson 1988). Barriers may also be imposed, for example, in order to protect information (sources) against access (first stage of communication). In the following part of this section, we will discuss a few important barriers in more detail.

Barriers in the first stages may follow on from low ski11 levels of senders and receivers, for example, with regard to the identification of communication needs and supply, and image building toward potential communication partners. In addition, the nature of the technology itself may well contribute to friction in communication. In innovation diffusion theory, it is emphasized that the higher the complexity and cost, the more time it takes before the technology has reached all potential adopters.

A further important source of barriers is the institutional framework, evident in certain law and regulatory regimes. One particular aim of barriers in this respect is the protection of information for economic reasons. For example, patent protection prevents dissemination and use of technical information in order to guarantee the patent holder an exclusive use of the technology for a certain period. Further barriers to communication have a socio-cultural background and affect both senders and receivers. Language is far the most important barrier here, preventing an adequate coding, decoding, and reception of messages. Language barriers include spoken, written and computer language, as well as the vocabulary used in communication. Vocabulary barriers may follow from different development stages of the technology involved (basic and applied), and from different organizational cultures of senders and receivers (Kamann 1994; Williams and Gibson 1990).

Many researchers have chronicled the influence of geographical space (see Charles and Howells 1992), both at the micro-scale (within a building, on a site) and the meso- and macro-scales. Within this framework, spatial isolation over a long time is regarded as a common source of socio-cultural barriers, reflected in different dialects, lower educational levels, and different ways of ‘doing things’ . In recent times many spatial barriers have lost their importance, but the concomitant socio-cultural barriers still persist on their original level.

To conclude, a large variety of potential barriers may hamper communication. Among them socio-cultural barriers seem to have increased in importance (cf. Gertler 1993; Lundvall 1988).

Table 1 Influences on communication with regard to technology transfer

Technology	Type of vehicle (medium) used Cost of technology Complexity of technology (Perceived) benefit of technology (profits, competitiveness)
Sender	Skill to identify demand Marketing and image building skills Skill to code message and to use information vehicles and media Organizational culture and vocabulary
Receiver	Receptiveness to information (demand) Skill to identify supply Skill to build the appropriate image Skill to use information vehicles (media) and to decode signals Organizational culture and vocabulary Capacity to take risks (through size, corporate position)
Institutional Framework	Market (de)regulation Trade system and fiscal tariffs Secrecy and intellectual property protection Systems of standardization and certification of products
Space	Culture and language Political borders and bridges Natural barriers and bridges Spatial communication networks Network capacity Physical distance City-size distribution
Time	Network capacity Time zones

We now turn to an exploration of intermediary institutes which aim to bridge barriers in technology transfer between universities and the business world.

3. University Transfer Institutes

University transfer institutes aim to bring demand ancl supply of academic knowledge together, particularly when no established relationships are at hand. It needs to be emphasized that many other forms of transfer may occur at the same time, such as joint research of academics and industry groups.

In the Netherlands, a system of academic transfer institutes was founded in 1981. In the first years, the system has been fully subsidized by the central government, but after 1986 subsidies were decreased and at the end terminated. Since then, these intermediary institutes took different development paths (Geenhuizen 1994). Some of them focused on the attraction and legal establishment of university contract research. Others have kept a broad perspective, also paying attention to the needs for knowledge among smal1 and medium-sized enterprises (SMEs) in the region. Since the late 1980s, a second development was the decrease of the amount of transfer projects carried out by transfer institutes. This decrease was associated with the emergence of new types of knowledge sources and intermediaries since the late 1980s, such as transfer agencies of higher educational institutes and regionally based innovation centres.

From the above it can be concluded that the concept of academic transfer centres in the Netherlands has been subject to different interpretations, whereas also the position of these centres in the market has changed, leading to some loss of activity.

A slightly different intermediary institute is the (American) technology licensing office (TLO) (Parker and Zilbermann 1993). This institute is specialized in patenting and licensing of academic innovations. We will now focus the remaining section on the TLO of Massachusetts Institute of Technology (MIT) (Cambridge) which is often associated with a strong high-technology development in the Boston Area. To give an indication of the growth of firms and employment: about a half-dozen new companies are formed around MIT licenses each year; MIT personnel and technology are involved in around

640 companies located in the state of Massachusetts, while these companies employ over 200,000 Massachusetts residents (1988) (Preston 1992).

The MIT Technology Licensing Office manages the patenting and licensing process for MIT and a number of associated institutes (Preston 1992; TLO 1994). Through the TLO, inventions are brought to market, including activities such as the evaluation of invention disclosures, filing of patents, and identification of companies interested in licensing. Under licenses companies are granted rights to MIT patents in return for their commitment to develop the inventions into products for the market. The major work of MIT TLO is to bring inventions, venture capitalists and companies together, by using highly specialized networks. MIT TLO does not provide venture capita1 itself, nor does it provide specific facilities for start-ups firms. Such facilities are supplied in the market in the Boston area.

Royalties derived from licenses are shared between inventors (one third), centra1 MIT (one third) and the MIT department where the invention has taken place (one third). This allocation of royalties guarantees a personal reward for the individual inventors involved, which is an important tool in advancing an entrepreneurial spirit at universities.

MIT TLO is staffed with Licensing Officers. Most of them have technical backgrounds (often engineering) and have spent more than ten years in industry, working in product development, marketing and/or business development. Each of the License Officers manages individual inventions from beginning to end. This includes managing of literature searches, market assessment, decisions on patent filing, marketing of the technology to potential licensees, negotiation of license agreements, and monitoring of licensee performance.

The success of MIT in patenting and licensing in collaboration with local (regional) business depends strongly on the qualification of its Licensing Officers. Through experience in industry they understand the process of bringing new technology to market. In addition, their educational leve1 is rather high (Ph.D. or M.B.A, sometimes with legal backgrounds). They have also developed a strong problem solving attitude and excellent communication and negotiation skills.

Further success factors of MIT TLO can be summarized as follows:

A huge stream of good technology produced by MIT scientists, as well as an entrepreneurial spirit in the faculties.

Clear and consistently applied policies and rules that separate scientific (educational) interests from commercial interests.

- Strong support for technology transfer from the upper administration of MIT.
- A simplified invention disclosure and review process, in order to smoothen the path for scientists to submit inventions for patenting.
- Straightforward licensing procedures, without long lasting steps and complexity. Most agreements can be signed in the Technology Licensing Office without further review.

An entrepreneurial climate in the Boston Area which can generate economies of scale and scope. For example, 'seed investors', consultants and executives, local incubation sites, 'venture forums' and related business networking clubs are abundantly available.

The above clearly applies to conditions in the US. Europe however, has a different business climate and different attitudes towards business in academia, leading to lower firm birth rates among academics.

With regard to the business climate one can observe the following differences. In the US, firm ownership is much more often shared among a team of people than in Europe. A small team offers the advantage of complementary skills, risk sharing and smaller vulnerability (aside from the disadvantage of conflicting interests). A second difference is concerned with the acceptability of failure. Failure in Europe may be a catastrophe in the career of a person, mainly because of stigmatization. In the US, this is not the case. Instead, starting a new future from scratch after failure is socially very well accepted.

In view of attitudes in the academic world towards business, the following differences need to be mentioned. Close academic - industry links are much more popular in the US than in Europe. In Europe, being involved in business as an academic has the negative connotation of having moved away from 'pure' (basic) science. This view is associated with an absence of 'role models' in Europe, i.e. examples of extremely successful university professors in business. Nurnerous 'role models' in the US make starting an own business socially more acceptable and attractive here than in Europe.

Furthermore, in the US it is much more common among bright graduates or Ph.D.'s to start an own business based upon ideas (inventions) developed during study. In Europe, such academics often start a career with large, established companies.

Most of the above discrepancy cannot simply be removed by means of policy measures. Various suggestions can nevertheless, be given in order to influence the entrepreneurial climate in Europe at universities and higher educational institutes (Charles and Howells 1992; Geenhuizen 1994):

- Make starting an own business popular in universities, and devote a part of the curriculum to entrepreneurial skills.
- Establish new innovation awards and make them well known in academia and the business world.
- Give successful academic entrepreneurs strong attention in the media in order to create 'role models'.
- Develop a package of measures which enables the part-time move of academics towards own business without the (immediate) loss of established rights (e.g., pension rights, upward move in the university system).
- Undertake public (academic) initiatives in order to offer a better supportive organization for academic spin-off, including the supply of 'incubator blocks', and secretarial and management (legal) services.

The latter suggestion brings our attention to science parks as a local planning tool. Science parks will be the subject matter of the next section.

4. Science Parks

Science parks are among the most popular local (regional) development tools currently in use in Western Europe, the United States and increasingly, Eastem Europe and the Pacific Rim. The fast majority of science parks has been established since the early 1980s. However, particularly the ones that have attracted much attention are clearly older, such as Stanford (1952) and Research Triangle (1959) in the United States, and Cambridge in the United Kingdom (1972) (cf. Currie 1985; Geenhuizen 1986; Gibb 1985; Luger and Goldstein 1989; Schamp 1987). Aside from 'euphoria', an increasingly critical view on achieved results of science parks has become evident in the course of time (cf. Bozzo et al. 1992; Luger and Goldstein 1991; Massey et al. 1992). This section will first discuss the concept of science parks and the variation evident in the implementation of this planning tool. Then, attention will shit? to results of science park development.

Science parks are conceived of here in a narrow sense. By using the United Kingdom Science Park Association defmition (Dalton 1992), science parks can be described as property based initiatives which:

- have forma1 and operational links with the university (or higher education institute)
- are designed to encourage the foundation and growth of knowledge-based business
- have a management function actively engaged in the transfer of technology and business skills to residents on site.

Initiatives to the establishment of science parks are usually taken by different actors. Aside from universities, one can observe participation of local (regional) govemments and development agencies, and various private actors such as real estate developers, investment banks, and large firms investing in accommodation (laboratories) (Nijkamp et al. 1994). While such a multi-actor situation is desirable regarding the need for different inputs in the establishment of the science park organization, it is has also the danger of diverging interests and goals. Universities usually aim at knowledge transfer for commercial reasons (sometimes by raising money from premises). Image building in order to attract excellent students and staff may be a further aim of universities. Local (regional) govemments, however, are often most concerned about employment growth, improvement of local images, and increase of the technology leve1 in the area. Again, different goals can be identifïed for private actors, such as profit maximization, improvement of image toward society, and access to technology.

There is a large differentiation between science parks regarding the accomodation and premises offered. Science parks usually provide facilities for newly established firms (eventually academic spin-off) by means of 'incubator blocks'. Many of them also provide premises and buildings for older firms in a park-like lay-out. By means of 'incubator blocks' conditions are created which advance the survival of newly established firms, such as cheap rent, flexible rent contracts and flexible space, and a range of supportive services, for example, secretarial services, managerial assistance, and (easy access to) venture capital. After a few years of residence in 'incubator blocks' surviving firms are expected to move into the park or elsewhere in the region.

The type of residents aimed at may also be different, witness for example, academic spin-off, regional companies, and R and D laboratories of multinationals. Common selection criteria for residents include a high technology character (e.g. evident in the amount of R and D) and relationships with the neighbouring university. The tightness in use of these criteria is however, different between science parks.

A further differentiation is evident in the location of science parks, for example, in economic core areas and peripheral regions. Such different locations may lead to divergent aims of science parks and different conditions for their growth. Regarding the latter, we mention a different embedding of science parks in regional-economie policy, differences in cost of premises, differences in investment incentives and (European) subsidies on infrastructure, and a different traffic infrastructure.

Much of the above indicated differentiation is evident in the application of the science park concept in the Netherlands (Table 2). Notable differences are the type of university involved (both universities of technology and general universities with a focus on humanities), regional location (both economic core regions and peripheral areas) and size of the parks (small-scale 'incubator blocks', as well as large-scale developments with a diversified accommodation).

There is also a remarkable variation in number of firms and employment growth between Dutch science parks (Table 2). For example, Enschede performs better than Leiden in view of number of firms, witness 102 in twelve years and 25 in nine years, respectively. Leiden however, aimed at the attraction of a few relatively large (foreign) companies from the beginning. Regarding their short time of existence, both Groningen and Wageningen seem to be relatively successful in attracting employment, witness a good 400 jobs in 4 to 5 years. This is strongly in contrast to Nijmegen.

Table 2 Science Parks in the Netherlands (1993)

Town and university (a)	Region (b)	Starting year	Size (ha)	Firms	Jobs
Enschede (T)	P	1981	18.5	106	1,115
Leiden (G)	C	1984	30	25	640
Groningen (G)	P	1988	60	51	460
Nijmegen (G)	1	1989	1.5	25	100
Wageningen(A)	1	1989	5.5	39	400
Amsterdam (G)	C	1991	20	20	150
Delft (T)	C	1992	30	15	27

a. T = University of Technology, G = General University, A = University of Agriculture.
b. Regional location in the Netherlands: P = Periphery, 1 = Intermediate location, C = Core (Randstad).
Source: Adapted from Bartels and Wolff (1993), p. 1039.

In general, the picture seems to be that the pace of employment growth on site is quite slow in the early years (Moore and Spires 1986). Indirect employment effects may follow on from local forward and backward linkages, and various multiplier effects in the region. And again, evidence suggests that much time is needed before a system of local and regional linkages is well developed. The time profile is thus one of decades rather than years before self sustaining growth on a significant scale occurs.

When considering impacts of science parks, various methodological issues arise. These issues will be discussed in the next section.

5. Evaluation of Science Park Developments

There are many reasons why ex *post* success of science parks cannot be assessed without difficulties (Geenhuizen 1994; Luger 1992). These difficulties are associated with the following circumstances:

- different extemal influences on science park growth, such as macro-economie conditions and military spending programs in the area (cf. Saxenian 1994);
- lack of reference values in view of various stages of park growth and lack of consensus about such values among different actors;
- shortage of required data;
- problem of counterfactuality.

An important factor that hampers the evaluation of success is the normative nature of success, implying the availability of reference values (standards). A standard growth trajectory of science parks has not yet been defined, mainly because of an expected differentiation between the development stages of science parks (Luger 1992). It seems to be that success must be measured in different ways over these stages. In addition, due to the multiple actor (objective) situation consensus about the definition of success is often absent. Success can be measured in terms of networks established on site (cf. Longhi and Quere 1993), new processes and products created in the region, direct and indirect employment growth, etc.

A further important methodological problem in the ex *post* measurement of success is counterfactuality. This problem follows on from the fact that 'outcomes' are observed in situations where parks exist. The question then is what would have happened in the region without the park (zero case). A proper solution would be a quasi-experimental approach, in which control groups and pre- and post-test observation are used similar to classical experiments in medical science (cf. Luger 1992). A further solution would be the use of in-depth, quantitative case studies in order to estimate indirect effects, following from induced start-ups and migration from the park, and from multiplier effects.

When we come to a summary of findings from various ex *post* evaluation studies (with previously mentioned shortcomings), the conclusion sofar is not unambiguous. It tends to an avoidance of high expectations about outcomes, be it in terms of employment, new firm formation, synergies between academics and business, or local technology transfer (Bozzo et al. 1992). However, the performance of science parks seems to improve over time.

In the remaining section we will discuss an ex *ante* evaluation framework for science parks initiatives, based upon practica1 experience listed in the literature (cf. Bolis et al. 1994; Bozzo et al. 1992; Geenhuizen 1986, 1994; Gibb 1985; Luger and Goldstein 1991; Massey et al. 1992; Nijkamp et al. 1994; Premus 1986; Preston 1992; Segal et al. 1985). The evaluation aims at a comparative analysis of altemative plans with a ranking of plans as the end-result. The analysis is multi-dimensional in nature by using various different evaluation criteria.

The evaluation criteria rest on the so-called Pentagon model, representing the decisive factors in regional development in a competitive network economy. Accordingly, the success of winning regions depends in particular on the following classes of factors:

- **hardware,** such as a good transport and communication system, and availability of land;
- **software,** such as particular qualities of the labour force (highly skilled, dedicated), local population (entrepreneurial spirit) and output markets;
- **orgware,** such as supportive services, and govemment policies favouring entrepreneurship and favouring knowledge as a resource;
- **ecoware,** for example, in terms of residential and cultural amenities, and creativity networks;
- **finware,** such as various forms of loans and venture capital.

The most important critical success factors in science park development are consistent with the above classes of the Pentagon model. The factors include the science park (university) itself and the region of location as follows:

1. A science park design which is attractive and which is consistent with apparent demand (hardware).
2. A region with a population receptive to technical progress and with a sufficiently developed knowledge infrastructure (software).
3. A university with large potentials for commercialization and an active identifi-

cation (activation) of these potentials (orgware).

4. Contractual arrangements at the university enabling a part-time shift of staff to business (orgware).
5. Easy access for start-ups to supporting services (orgware).
6. Excellent science parks managers (particular in communication) (orgware).
7. A region (city) well endowed with high quality residential amenities (ecoware).
8. Easy access for start-ups to venture capita1 (finware).
9. Low needs for a profitable exploitation of the park during the first years (finware).

The above factors indicate the vita1 role of particularly orgware in science park development. In addition, many factors are associated with conditions for communication and networking.

Next step in the operationalization of the evaluation framework is to find valid indicators for the above factors. Various suggestions for operational variables are given in Annex 1, but it needs to be emphasized that there is a problem of data availability . Data problems may be solved by means of assessment by researchers and (for particular cases) by experts. In addition, the measurement leve1 of the variables may be different, for example, binary , ordinal and cardinal. Such a situation can however, be handled in particular designs of multi-criteria analysis (MCA) (Nijkamp et al. 1990).

Multi-criteria techniques enable to evaluate a discrete number of altemative options (plans), by means of explicitly formulated criteria. It allows for a different weighting of scores on these criteria, dependent upon the scientific relevance and interests of various actors in the planning process. It needs to be emphasized that MCA is only a supportive tool aimed at making new information available to the benefit of decision makers.

The use of MCA in the evaluation of science parks is not entirely new. Some interesting experiences have recently been achieved in a cross-national comparative study of various high-technology developments (Bolis et al. 1994). The results of this evaluation are summarized in Annex 2.

Many issues in science park growth are not clear yet because a short time of existence has prevented a thorough investigation. Time is now coming that research can be done in a systematic way, for example, by means of ex *post* quasi-experimentation and by using the results as an input to ex *ante* evaluation for new science park plans.

6. Concluding Remarks

Universities are major sources of inventions that can be commercialized and concomitantly, contribute to economic growth. The process of bringing inventions to market is however, fraught with many obstacles. This paper has discussed the way in which patented technology is brought to market by Massachusetts Institute of Technology (MIT) in the Boston area. A striking feature of MIT is its strongly developed network which involves all crucial actors in technology transfer, namely scientists, companies and venture capitalists. Whether the model of MIT can be replicated elsewhere is dependent upon the local (regional) entrepreneurial culture and industrial networks. Therefore, a wise policy in advancing technology transfer would be to give attention first to local barriers. A second step would then be to adopt selected success features from the MIT model which clearly fit local circumstances.

Science and technology can no longer be neglected by local planners as a major source of competition in a knowledge-based economy. Within this framework, the paper has focused on university science parks as a local planning tool. It has become evident that expectations on employment should be modest, at least for the first years. However, carefully planned science parks embedded in a comprehensive knowledge policy, may have good outlooks for growth. This paper has discussed a preliminary set of success factors in such a careful planning. There is, however, a need for a more elaborate analysis which should be achieved in the near future following the maturation of large numbers of science parks.

Acknowledgement

This analysis has benefited from interviews with Mr. L. de Lange (Genera1 Manager of Zemike Science Park in Groningen (NL)), and Dr. Christa Jensen (License Officer at MIT TLO) and John Preston MBA (Director of Technology Development at MIT, Cambridge US).

Annex 1 Operational variables in MCA of science parks

Hardware

1. type of science park design (layout); realistic match between accomodation (buildings) and demand based on a feasibility study .

Software

2. share of skilled technicians in economically active population; share of pupils selecting beta subjects in secondary school; number of research institutes and R and D departments per 1000 firms in the region.

Orgware

3. number of patent applications per 1000 university researchers; cornrnunication between science park officers and research departments about inventions to be expected .
4. package of (legal) arrangements conceming pension rights, insurance, upward promotion in university, etc.
5. service package including secretarial, legal, management (business plan) and marketing support.
6. science parks managers excellent in personal cornmittment, cornmunication and networking, and problem-solving .

Ecoware

7. share of medium and high segment in housing stock; amount of green area in living quarters; intemational schools, etc.

Finware

8. number of venture capita1 firms per 1000 firms in the region; access to venture capita1 firms via the science park.
9. a financing structure of the park that avoids the need for a profitable exploitation during the first years.

Annex 2 Summary of 'Knowledge Transfer and Science Parks' (Bolk et al. 1994)

This study aims at a cross-national ranking of selected high-technology developments in various countries. The evaluation is based upon eight criteria as follows:

1. university propulsive role (existinginon-existing);
2. promoting actor, regarding type (public/private) and spatial framework (e.g. local - national);
3. origin in the region, e.g. a new development (city of science) or an old pole;
4. connection with universities (existinginon-existing);
5. developed sectors on site (high-, medium- and low technology);
6. intermediary between university and business world (existinginon-existing);
7. type of funding sources for start-ups (public/private);
8. type of funds for technology policy (public/private).

An interesting methodological aspect of the evaluation is the use of different scores (for the same criteria) in two tests (tl and t2) and different weights (for the same scores) in two scenarios (sl and s2), leading to four rankings. The aim of this approach is to test the sensitivity of the ranking to priorities given to 'knowledge transfer support factors' and 'financial factors'. The four rankings are:

	tl-sl	tl-s2	t2-s1	t2-s2
Cambridge (UK)	1	2	1	2
TP Milano	2	7	3	7
RA Trieste	3	4	2	4
BIG Berlin	4	10	4	10
Sophia Antipolis	5	3	5	3
TP Plan Japan	6	1	6	1
Heriot Watt Edinburgh	7	12	7	12
TP Bari	8	5	8	5
Stanford Califomia	9	16	9	16
TIP Berlin	10	14	10	14
Rhone Alpes France	11	11	11	11
Aston Birmingham	12	6	12	6
Route 128 Boston	13	8	13	8
Montpellier France	14	9	15	9
STP Torino	15	13	14	13
Research Triangle	16	15	16	15

The rankings indicate a different role for 'knowledge support factors'(emphasis in scenario 1) compared with 'ftnancial factors' (emphasis in scenario 2). However, the rankings in the two scenarios are certainly not reverse, witness a certain overlap between developments (parks) with a low ranking and the ones with a high ranking.

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